KONCEPT ŠTIHLÉ VÝROBY V OBLASTI HUTNÍHO PRÚMYSLU

LEAN MANUFACTURING CONCEPT IN METALLURGICAL INDUSTRY

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Abstract

Blast-furnace procedure belongs to the most demanding manufacturing processes. It poses great claims on the input raw materials, process run regulation, as well as on the utilized volume of human capacity ensuring the process is running efficiently. Continuous increase of prices of all input materials forces the metallurgical companies to increase the efficiency of the entire process. The competitive power of the manufacturing system can be realized using a number of modern approaches. Initially, the lean manufacturing concept was applied in mass production of automobiles. However, its versatility and efficiency meant it has expanded to other industrial branches. Lean manufacturing concept utilization can bring significant savings in the metallurgical industry branch which will help the companies to compensate for the increasing prices of raw-materials. Lean manufacturing system application can find wide use in metallurgical manufacturing, above all in combination with TMP method - Total Productive Maintenance. This method represents part of organization production philosophy which includes all the company departments and it introduces mutual interconnection of maintenance, manufacturing with technical provisions for construction and technology. TPM tries to remove the traditional division of employees into those who work with the given equipment and those who are responsible for maintenance. It is caused by the fact that it is the worker who uses the production equipment and he the first one who can spot functional irregularities of the machine and the eventual sources of future breakdowns. The largest possible number of diagnostic and maintenance activities is transferred from maintenance department directly into production, within the frame of TPM. Great importance of this concept utilization can be seen mainly in current problems of metallurgical companies when financing separate maintenance is very costly. TPM concept in metallurgical production can be naturally connected with continuous improvement process utilization which has currently been very popular in manufacturing companies. The article deals with analysis of utilization of these methods in metallurgical production processes.

Keywords: metallurgy, lean manufacturing, costs, maintenance

1. INTRODUCTION

Iron and steel manufacturing belong to the most complex manufacturing procedures. The complex nature is mainly caused by its technological demandingness but also by high amount of necessary input materials. In this branch as well as in other follow-up branches such as: forming processes, foundry industry and engineering, great stress is laid on economic side of the manufacturing processes. New modern methods from other industrial branches are used in order to increase the efficiency of production. These methods make it possible to increase the production potential but also to save some very expensive resources. One of the options is the utilization of Lean Manufacturing principles which have successfully been applied especially in automobile industry. However, Lean Manufacturing concept uses many tools which have been applied in completely different environment than in the metallurgical industry. That is why it is important to
analyse whether it is possible to implement this concept as a whole in heavy industry as well or whether only selected segments of this philosophy must be used.

Lean Manufacturing is mainly focused on trying to [1]:

- Terminate all useless activities.
- Adjust material flow so that it is simple and straightforward.
- Close down useless warehouses and buffer stocks.
- Include all employees in the decision-making and innovation process.
- Use Pull principle in production management (Pull method).
- Remove all materials, tools, jigs which are not regularly used from production areas.

The objective of this article is to judge whether it is possible to apply Lean Manufacturing concept in the sphere of: blast-furnace production, production of steel, forming, foundry industry and engineering. The task is to answer the following research questions:

a. Is it possible to implement Lean Manufacturing in metallurgical industry and other follow-up branches?

b. Is it possible to apply the basic tools of Lean Manufacturing in heavy industry?

2. PROBLEM FORMULATION

Lean Manufacturing does not mean purposeless reduction of costs. Its purpose is, above all, to provide maximum added value for customers. Lean approach is the way to higher production of a company, lower overhead costs, more efficient utilization of its area and production machinery. Lean Manufacturing can not work without close contact with product development and technical preparation of production, logistics and company administration.[2] According to new estimates, all economic subjects in economically developed countries spend approx. 10% national income on maintainance.[3]

The first steps towards Lean Manufacturing have these four objectives: improving quality, elimination of losses, shortening the production realization time, and reducing the total costs. Loss in metallurgical company means any activity which requires time, resources or space but does not bring value to the product of to the entire manufacturing process. Some activities, such as material transfer during production are necessary, but they do not add value. The total costs are both direct and indirect costs related to manufacturing of a product or to preparation of a service. If an organization wants to be successful it must continuously compare the prices of its products and services and its operational costs. Should its prices or its operational costs be too high, it can lose market share or its profit. If a lean company wants to cut its total costs it must eliminate the losses and reduce the time necessary for realization. A wide range of efficient tools can be used in order to meet the objectives within the frame of Lean Manufacturing process. The most commonly used tools of Lean Manufacturing concepts are: Kaizen, 5S System, Poka-Yoke, TPM, FTA. These tools are mainly used in automobile industry. Metallurgical production, with its continuous character, has completely different specific features than the production processes in automobile industry.

The application of lean manufacturing is interesting in the area of material cutting – cutting of heavy plates. A wide product range is typical for operations producing cut shapes from heavy plates. [4]

3. LEAN MANUFACTURING SYSTEMS

The basic tools of Lean Manufacturing are mainly oriented towards cutting the costs. They are methods looking for existing sources of wasting, but they also identify and minimize potential damages. All basic tools
of Lean Manufacturing were initially used in automobile industry. The conducted research considered their possible utilization in production of iron and steel and other follow-up industrial processes.

3.1 Kaizen system of continuous improvement

Improvement within the scope of Kaizen is seen as a continuous process consisting of small steps. Small changes can be found and realized in every sphere, in every department and they aim at improving the current situation. The effort to do things in a better way is the main driving power of Kaizen strategy. The scheme of continuous improvement by means of small steps is basically the opposite of improvements achieved by large investments and costly projects. These processes formulated in reengineering philosophy are typical for western approach to improvement. Implementation of Kaizen principles does not require any special techniques, but it uses well-proven methods which are known and, in many cases, they have been used for long time: orientation on customers, absolute quality control, automatization of processes, quality control groups, improvement proposal system, discipline at workstations, Just-in-Time, zero defect movement, new product development, and creative teamwork. Continuous improvement processes can, with regards to their universal character, be applied in all industrial branches. It does not have to be about demanding and expensive changes, but they are tiny improvements which can be found in metallurgical and foundry industry as well.

3.2 Method 5S

5S refer to the first letters of five Japanese words describing good management. When 5S are not present it means wasting, low efficiency, lack of self-discipline, low working morale, bad quality, high costs and inability to deliver. Five steps of good management are: Seiri (sort), Seiton (set in order), Seiso (shine), Seiketsu (sustain), Shitsuke (standardize). 5S System mainly relates to order and discipline at the workstation. It is important to optimize the number of items at the workstation and to eliminate those which have not been used by the workers for a long time. 5S System is also linked with organization of work space and its identification. Figure 1 shows identification of work space in a company engaged in forming and heavy engineering. The most significant utilization in metallurgical industry can be seen in control and keeping order at the workstations, but also in the area of labour protection rules building and safeguarding. Forming, foundry and engineering companies can, with regards to their great number of tools necessary for realization of their work activities, use this system to improve their management and maintenance. 5S System can also significantly increase the efficiency of repairs and maintenance system in these organizations.

![Fig. 1. Identification of work areas in a company with forming procedures](image)

5S system is widely used in the processing of discarded products, which allows the reuse of materials. The recycling process of used electronic equipment makes it possible to retrieve ferrous etals, non-ferrous and precious metals, glass, plastic and other raw materials. [5]
3.3 Poka-Yoke System – prevention of occurrence of errors

When this method is applied, it makes the process resistant against random and unintentional mistakes of workers (omissions, confusion of components, and misunderstanding of the right procedure). Poka-Yoke systems use various organizational measures and simple technical systems aimed at prevention of occurrence of defects.[6] Poka-Yoke method can be used for improvement of manufacturing processes, especially in places where the workers carry out repeated and stereotype operations. The method can be understood in two levels. Optimization of a process so that it is impossible to make a mistake. If the occurrence of mistakes can not be prevented, the manufacturing process must be changed in such a way to make a mistake obvious immediately after it has occurred and to make it possible to remove the mistake.

Poka-Yoke system can also be utilized in metallurgical production for elimination of work injuries. Production processes with potentially dangerous operations which can be influenced by lack of attention of a worker can be limited by using suitable technical measures. Utilization of Poka-Yoke technique can be seen in all areas: blast-furnace production, sintering, production of steel, foundry industry, and engineering industry.

3.4 FTA - Failure tree analysis

Failure tree analysis is a deductive technique which is focused on concrete accident or system error and it provides a method which can be used to determine the cause of events. It creates a graphic model illustrating various combinations of errors of production equipment or workers which can cause production system failure.[6] The method can be applied in all areas. The largest utilization of this method can be found in situations where production is realized as a sequence of a number of follow-up activities. An example of application of Failure tree analysis is illustrated in figure 2 where a mistake and the cause of this mistake are graphically identified in a process of pipe production. The method can also be used for identification of problems among the individual manufacturing procedures (forming – engineering, production of steel – forming, foundry industry – engineering).

![Fig. 2. Application of Failure tree analysis in pipe production](image-url)
3.5 TPM - Total Productive Maintenance

Total Productive Maintenance develops preventive and predictive maintenance approaches and it establishes new elements such as autonomous maintenance, engaging small team groups, visual management or elements of safe workplace.[6] The main task Total Productive Maintenance must deal with is to eliminate interruptions in operation of machines, thus increasing the efficiency of production equipment. Maintenance in the traditional approach is mainly focused on interruptions as a result of machine or equipment breakdowns. TPM also covers areas such as losses when a machine is running with broken components or even when wrong technological procedure is used or when the workplace is arranged in an unsuitable way, which can, for example, lead to unnecessarily long set-up time. Total Productive Maintenance philosophy consists of the following programmes: programme of autonomous care of equipment, programme of planned maintenance, programme of education and training, programme of planning for new equipment and components. Total Productive Maintenance concept utilization is possible mainly in processes which are not purely continuous. In case of blast-furnace process, production of steel, but also in foundry processes it is possible to use this system in order to cut maintenance costs. Service staff can be trained to carry out many small interventions and repairs. Great utilization can be seen in non-continuous production processes such as heavy engineering.

4. RESULTS AND DISCUSSION

The main aim of Lean Manufacturing is to try to remove maximum amount of potential sources of wasting. In every type of production procedure, it is possible to minimize activities which do not add value and which require overproduction, waiting, transport, useless processing, and large stock or unnecessary movements. Lean Manufacturing can also be looked upon from the point of view of the tools it uses: Kaizen, 5S, Poka-Yoke, Failure Tree Analysis, and Total Productive Maintenance. All these tools are successfully applied mainly in automobile industry. Their utilization in metallurgical industry and other branches of heavy industry has many specific aspects. Possible applications of these methods are illustrated in table 1.

Kaizen, a process of continuous improvement, is the most universal of the tools. This technique can be successfully applied in all monitored areas. The method of good management 5S has found its best application within the frame of forming procedures, in foundry and engineering industries. Prevention of occurrence of errors (Poka-Yoke) often requires interventions into technical equipment of production machinery or changes in the technologies. That is why its application in blast-furnace plant or in production of steel is difficult. In the sphere of forming procedures, foundry industry or in engineering, however, it can find its adequate use.

Table 1 Possible utilization of Lean Manufacturing tools

<table>
<thead>
<tr>
<th></th>
<th>Production of iron</th>
<th>Production of steel</th>
<th>Forming process</th>
<th>Foundry industry</th>
<th>Engineering</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kaizen</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>5S Method</td>
<td>Yes</td>
<td>Limited</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Poka – Yoke</td>
<td>Limited</td>
<td>Limited</td>
<td>Little</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Failure Tree Analysis</td>
<td>Limited</td>
<td>Limited</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Total Productive Maintenance</td>
<td>Yes</td>
<td>Yes</td>
<td>Limited</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Failure tree analysis is especially used in case of multiple operations or among the individual production procedures. Its utilization in metallurgical processes is limited. Forming and foundry procedures are very suitable for its utilization. Total Productive Maintenance makes it possible to significantly cut the costs of
production maintenance. From this point of view, this method is usable in all the discussed areas. Increasing pressure to cut the costs will also force metallurgical companies to use a more efficient method of maintenance of their production equipment. Total Productive Maintenance offers an interesting alternative how regular maintenance of production capacities can be ensured using employees currently working for a company.

5. CONCLUSION

There are many restrictions of application of Lean Manufacturing in metallurgical industry. It will be very difficult to adjust material flow in this industrial branch. It is also not possible to eliminate large stock of input raw materials the company must keep due to the necessity to adjust them before actual production. Several techniques used in Lean Manufacturing are also designed especially for non-continuous production systems. The utilization of methods of continuous improvement is interesting and they can be recommended without any constraints. The principles of good management and tidy workplaces can be applied as well. Total Productive Maintenance system can be used to increase the efficiency of maintenance, which can bring significant savings of costs. System of error prevention (Poka-Yoke) can be used for protection of workers carrying out risky operations when simple technical measures can prevent mistakes caused by lack of awareness. The defined research questions can be answered according to the presented conclusion using the following abbreviated form:

a. Is it possible to implement Lean Manufacturing in metallurgical industry and other follow-up branches? Yes, but it is necessary to adjust the implementation according to specific conditions of a manufacturing plant. It is not possible to use Lean Manufacturing concept from automobile industry without adjusting this system to conditions of metallurgical companies.

b. Is it possible to apply the basic tools of Lean Manufacturing in heavy industry? The utilization of basic tools of Lean Manufacturing in heavy industry is realistic; however, it is necessary to take into account the continuous character of its production. In case of large-scale metallurgical aggregates, the possibility of realization of more demanding technical and technological changes will probably be very limited. The tools related to improvements, innovations and maintenance can be implemented without fundamental modifications in all the monitored areas.

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REFERENCES